VISCOSITY MEASUREMENTS OF A SLAG SAMPLE FROM PACIFIC ENERCON LTD.

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by

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SUMMARY

Viscosity measurements, as a function of temperature, were made in CANMET's high-temperature viscometer for a copper slag sample used as the charge material for mineral wool production at Pacific Enercon's Grand Forks, B.C., plant. Viscosities varying from 0.935 to 0.12 Pa.s were obtained for the temperature range 1185 to 1510°C. The melting behaviour of the sample was also measured by a heating microscope, melting beginning at around 1175°C.

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INTRODUCTION

Pacific Enercon of Grand Forks, B.C. requested that CANMET measure the viscosity of a copper slag sample which is used for mineral wool production. Melt viscosity is an important parameter in determining the spinability of the melt and the quality of mineral wool produced (1,2). This work was carried out on a full cost recovery arrangement.

EXPERIMENTAL WORK

SAMPLE

A sample for viscosity study was taken from the cupola spout before being fiberized into mineral wool. Its chemical composition, in wt % reported by Warda, is given in Table 1(3).

Table 1 - Sample chemical composition

FeO	CaO	SiO_2	Al_2O_3	MgO
18.4	20.9	49.8	7.3	0.5

A Leitz heating microscope type II A-P was used to determine the melting point. A series of photomicrographs was taken during the heating of a small specimen in air. The shrinkage and change of the image of the specimen indicate the melting behaviour of the sample. The results are shown in Fig. 1. The sample starts to melt at around 1175°C.

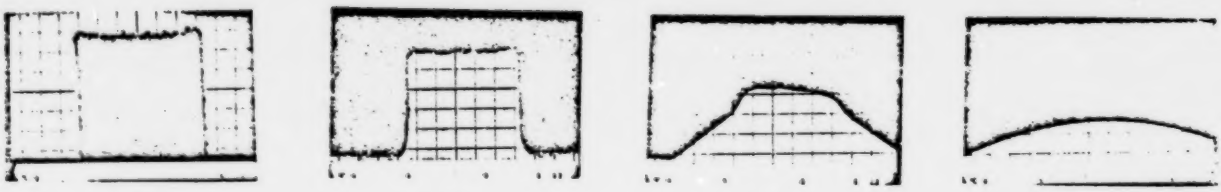

Fig. 1 - Series of photomicrographs showing silhouettes of the sample during heating

VISCOMETER

The high temperature viscometer system is shown schematically in Fig. 2. It consists of (a) an induction furnace (b) a viscometer incorporating a variable speed Brookfield torque meter with a molybdenum crucible and bob, and (c) a gas train.

Induction heating is used to melt the sample by coupling an induction generator to the molybdenum crucible. The heat loss from the furnace is minimized by placing the molybdenum crucible inside an alumina crucible, the gap between the two crucibles being filled with zirconia grains as insulation. In addition, an alumina tube lined with molybdenum foil is used as a heat shield, and a molybdenum heat reflector plate is placed on top of the alumina tube. The whole assembly is set inside a silica tube which, in turn, is snugly fitted inside the induction coil. The zirconia

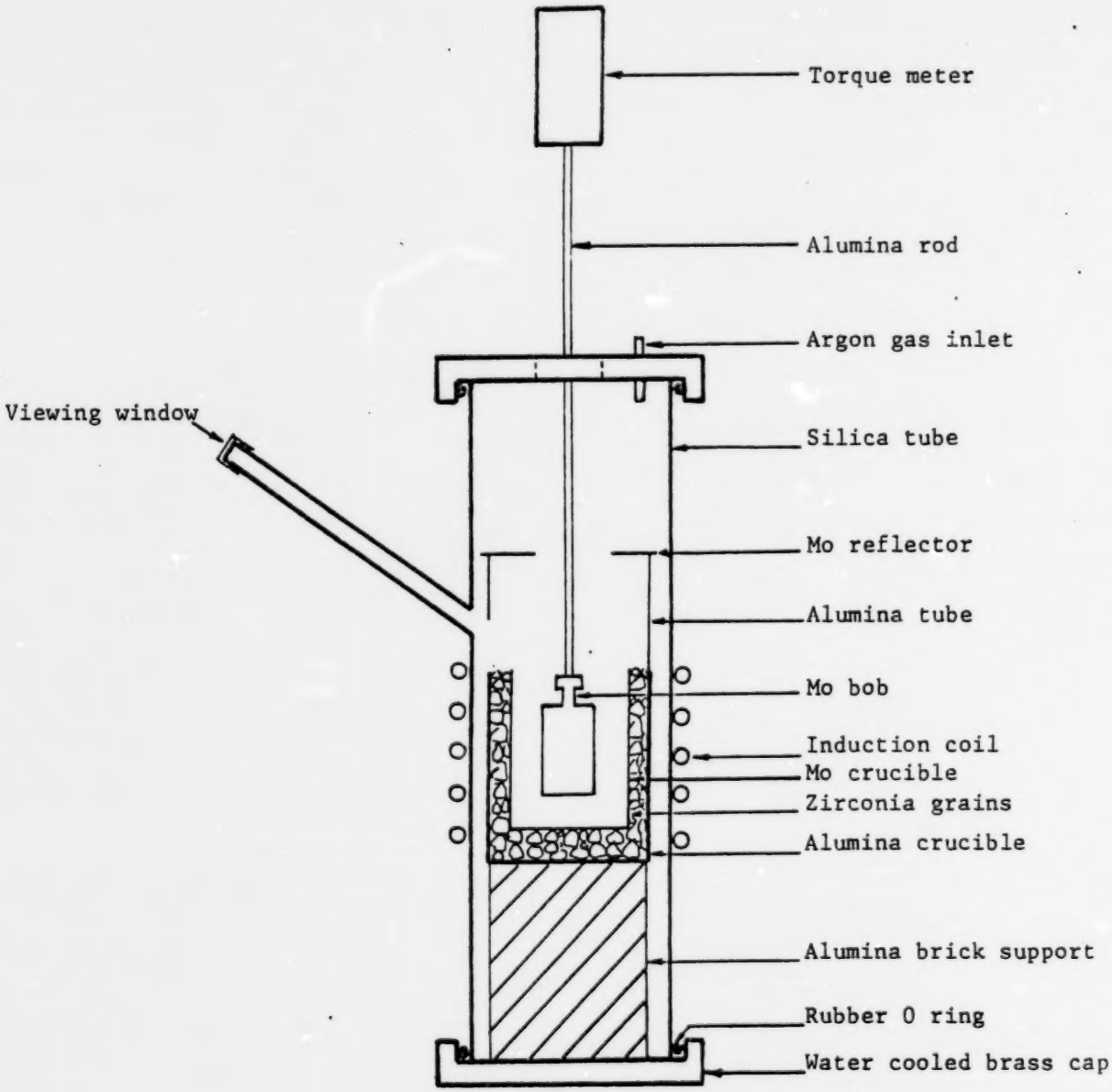

Fig. 2 - The viscometer set-up

grains provide a second useful function - at high temperature, zirconia becomes a semiconductor and when coupled to the induction generator will produce additional heat for melting.

The torque meter is a Brookfield Rheolog type viscosity transmitter, Model RVG, equipped with an 8-speed transmission. The Rheolog sensing head (transmitter) output is fed into a pneumatic-to-electric transducer giving an output of 0-10 mv which, in turn, is fed to a recorder. The viscometer system was calibrated using standard silicone oils. The signal from the transmitter was recorded in terms of millivolts for a given bob rotation speed for each standard silicone oil.

The viscosity measurements are carried out under a positive pressure of argon mixed with 10% nitrogen. The nitrogen serves to eliminate the ionization (arcing) of the argon gas at high temperature.

VISCOSITY MEASUREMENT

About 130 g of sample were required for the determination. The sample was calcined at 800°C before viscosity measurements were made. After the sample-filled molybdenum crucible had been properly positioned in the induction furnace, the system was flushed with argon gas for about 5 min. The furnace temperature was then raised to the desired minimum for the viscosity measurement. Once the furnace had reached thermal equilibrium, the bob was lowered into the melt and the torque meter motor started. Viscosity readings were recorded continuously as the furnace temperature was increased to a maximum of 1510°C. The melt temperature was monitored simultaneously by an optical pyrometer through a viewing window. The melt was then cooled and viscosity readings taken until a crust appeared on the melt.

RESULTS

The viscosity data are presented graphically as a function of temperature in Fig. 3. Viscosity decreases as temperature increases. Several viscosity values, taken from the viscosity-temperature curve in Fig. 3, are listed in Table 2.

Table 2 - Viscosity data

Temperature °C	1185	1200	1250	1300	1350	1400	1450	1500
Viscosity, 10^{-3} Pa.s (centipoise)	935	800	517	341	233	171	138	122

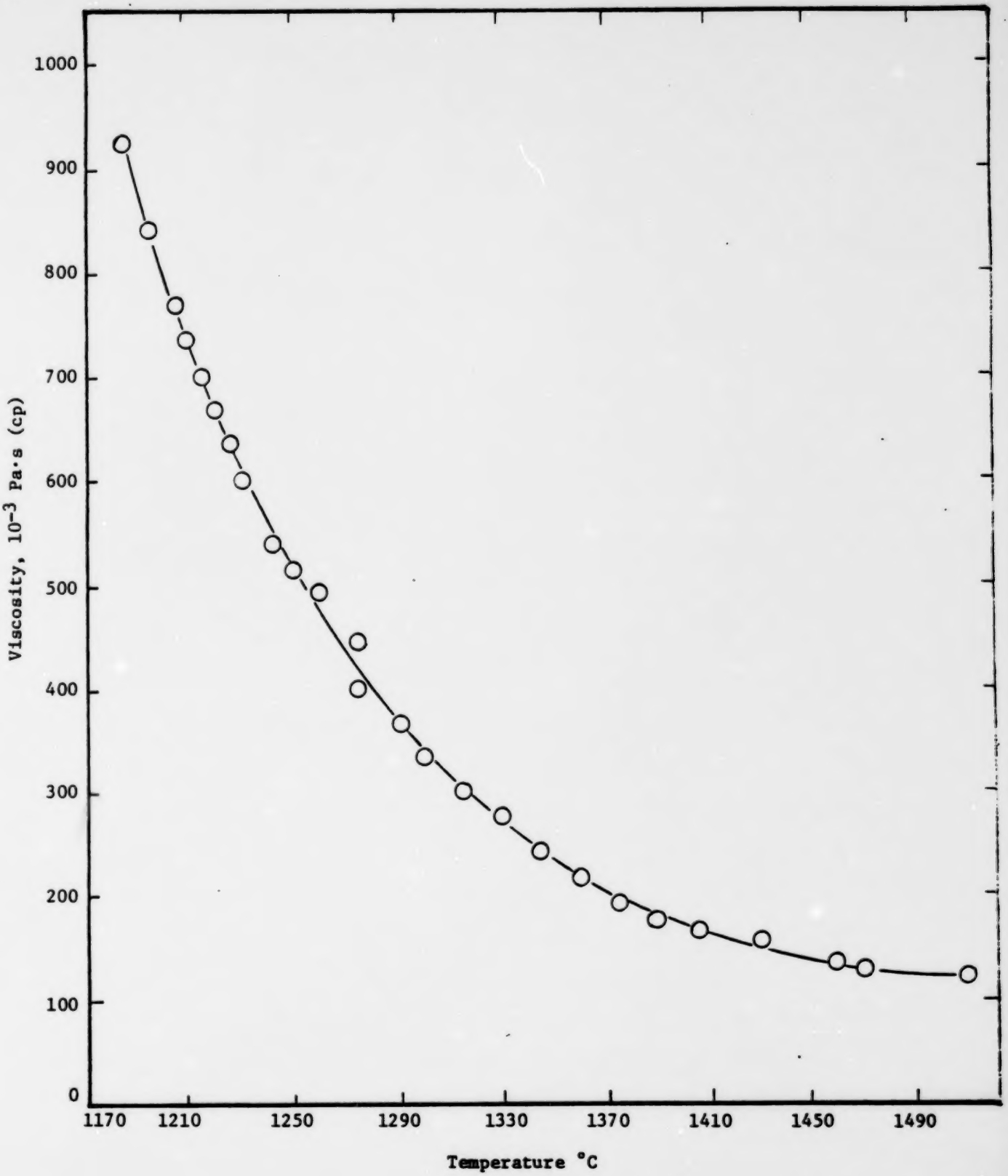

Fig. 3 - Viscosity as a function of temperature

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